FINAL REPORT
PROJECT GH 7602
MICRO 7805

A SURVEY FOR BATHING RELATED DISEASE AMONG COTTAGERS ON MISSISSIPPI LAKE, LANARK COUNTY, 1976

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MICROBIOLOGY REPORT

LABORATORY SERVICES BRANCH

ONTARIO MINISTRY OF THE ENVIRONMENT

JUNE 1978

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SUMMARY

Cottagers on Mississippi Lake were surveyed for the incidence of disease associated with swimming and for their swimming habits. This was carried out along with an intensive study of water quality and shoreline characteristics. The largest cause of bathing related disease, 57 of 67 reported infections, was infection of the ear; 3.28% of bathers at cottages suffered ear infections. The frequency of ear infections in the population of swimmers was significantly associated with the amount of swimming in the lake. Males and females were infected at equal rates. Young people suffered ear infections after bathing at a significantly greater rate than adult bathers. Frequency of water contact was probably greater in young people than in adults and may explain the greater number of ear infections in young swimmers.

The survey of water quality showed that the presence of Pseudomonas aeruginosa was associated with bathing sites or fecal pollution whereas fecal pollution was associated with a number of factors like cattle watering sites, inflowing streams, or defective septic tanks.

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INTRODUCTION

The Ministry of the Environment for Ontario (MOE) has established, as with most other regulatory agencies, guidelines for bacteriological water quality of recreational lakes based mainly on the coliform index. Until recently it was generally agreed that no conclusive evidence of a correlation had been found between coliform levels in recreational waters and the incidence of illness in the bathing population. Recent studies (7) have shown a relationship between microbial indicators and health effects at marine bathing beaches. New standards, possibly based on fecal streptococcus or Pseudomonas aeruginosa, have also been proposed by several authors (1).

Eye and ear infections caused by Pseudomonas aeruginosa are a major hazard of swimming (1). A recent MOE survey of several lakes in southern Ontario (2), to which the results of this study were added, showed that a median value of 3.29% of swimmers at cottages acquired ear infections. A lower level of infection of about 2.0% was found in lakes which on previous MOE surveys had been credited with very good water quality (e.g. 8). Such infections caused by P. aeruginosa are not reported to the Medical Officer of Health, and so accurate data for the whole of Ontario are not available.

There are about 250,000 cottages on lakes in Ontario (MNR-Policy Research Branch, 1972), with about three to four persons who swim per cottage. If we apply the lower incidence of ear infections to all these swimmers, then we see that each summer 17,500 (2.0% of 875,000) people who bathed at their cottage likely were infected. If a relationship can be found between bacterial densities of P. aruginosa in water, and the health of a population using a bathing area, then the relationship should be the basis of water quality standards.

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Medical doctors usually advise cottagers that otitis externa (the ear infection caused in swimmers by P aeruginosa) is not necessarily a waterborne disease. An example of this is given from a local newspaper (3). It is quite possible that those bathers who carry P. aeruginosa as part of the flora of the ear are actually those who are at risk. This poses a major obstacle to those who would use P aeruginosa as the basis of water quality standards.

The 1976 study of Mississippi Lake was the first conducted by the MOE to gather information on cottager's infections and densities of P. aeruginosa in lake water and sediments from corresponding locations. The results were encouraging, and information obtained will improve such surveys in the future.

Methods

Data was gathered on a simple interview form (Figure 1). The forms were circulated to the cottagers by the Cottage Pollution Control Program field crews. The results of the bacteriological survey of the lake have been reported separately (4).

Results and Discussion

The new data from the survey is listed in Table 1, and the frequency of various infections reported by bathers is displayed in Table 2. The response to the survey was reasonably good since 67.2% (i.e. 591 of 800) of all lakefront cottages took part in the survey. m 880 ²

Some Characteristics of the Infections

Most of the infections occurred in the summer; 93.3% of those swimmers who became infected did so in July and August (Table 3). The most important sampling period for public health problems is obviously the summer.

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Ministry of the Environment
Ontario

NAME

ADDRESS

LOCATION ON Lake

INTERVIEW NO.

INFORMATION ON WATERBORNE INFECTIONS

Q1. In the last year, has any one who uses this cottage suffered from ear infections, eye infections, boils, intestinal upsets, or swimmers itch?

Yes.....1
No.....2
NR.....9

Q2. List all the members of the family who use the cottage:-

No.	Name	Sex	Frequency Of Cottage Use	Frequency Of Water Contact	Swimming Location	Wears Ear Plugs or Cap
1			1 2 3 4	1 2 3	1 2 3 4	1 2
2			1 2 3 4	1 2 3	1 2 3 4	1 2
3			1 2 3 4	1 2 3	1 2 3 4	1 2
4			1 2 3 4	1 2 3	1 2 3 4	1 2
5			1 2 3 4	1 2 3	1 2 3 4	1 2
6			1 2 3 4	1 2 3	1 2 3 4	1 2
7			1 2 3 4	1 2 3	1 2 3 4	1 2
8			1 2 3 4	1 2 3	1 2 3 4	1 2
			1=all summer 2=part of summer 3=week-ends 4=other	1=less than 3 times/wk 2=3-5time/wk 3=more than 5 time/wk	1=cottage only 2=other locations on lake 3=pools 4=other	1=yes 2=no

CIRCLE THOSE WHO SUFFERED FROM INFECTIONS AS IN Q1.

FIGURE I

FIGURE I REVERSE

AFFLICTED PERSON #_____ NAME_____ INTERVIEW NO.:

AFFLICTION: Ear Infection.....Yes=1 No=2 NR=9
Eye Infection.....1.....2.....9
Boils.....1.....2.....9
Intestinal Upsets.....1.....2.....9
Swimmers Itch..... ..1.....2.....9

OCCURENCE: SUMMER: MONTH:
Ear Infection.....Yes=1 No=2 May=1 Jun=2 Jul=3 Aug=4 Sep=5 NR=9 NA=8
Eye Infection.....1....2 ....1.....2.....3.....4.....5. ...9....8
Boils.....1....2 ....1.....2.....3.....4.....5. ...9....8
Intestinal Upsets.....1....2 ....1.....2.....3.....4.....5.. ...9....8
Swimmers Itch.....1....2 ....1.....2.....3.....4.....5. ...9....8

TREATMENT: DOCTOR NAME ADDRESS
Ear infection.....Yes=1 No=2 NR=9 NA=8 _____ _____
Eye infection.....Yes=1 No=2 NR=9 NA=8 _____ _____
Boils.....1....2....9....8 _____ _____
Intestinal Upsets.....1....2....9....8 _____ _____
Swimmers Itch.....1....2....9....8 _____ _____

MEDICATION....Yes=1 No=2 NR=9 NA=8 Type:_____ NR NA
PREDISPOSITION....1....2....9....8 Reason:_____ NR NA

AFFLICTED PERSON #_____ NAME_____ INTERVIEW NO.:

AFFLICTION: Ear Infection.....Yes=1 No=2 NR=9
Eye Infection.....1.....2.....9
Boils.....1.....2.....9
Intestinal Upsets.....1.....2.....9
Swimmers Itch..... ..1.....2.....9

OCCURENCE: SUMMER: MONTH:
Ear Infection.....Yes=1 No=2 May=1 Jun=2 Jul=3 Aug=4 Sep=5 NR=9 NA=8
Eye Infection.....1....2 ....1.....2.....3.....4.....5. ...9....8
Boils.....1....2 ....1.....2.....3.....4.....5. ...9....8
Intestinal Upsets.....1....2 ....1.....2.....3.....4.....5.. ...9....8
Swimmers Itch.....1....2 ....1.....2.....3.....4.....5. ...9....8

TREATMENT: DOCTOR NAME ADDRESS
Ear infection.....Yes=1 No=2 NR=9 NA=8 _____ _____
Eye infection.....Yes=1 No=2 NR=9 NA=8 _____ _____
Boils.....1....2....9....8 _____ _____
Intestinal Upsets.....1....2....9....8 _____ _____
Swimmers Itch.....1....2....9....8 _____ _____

MEDICATION....Yes=1 No=2 NR=9 NA=8 Type:_____ NR NA
PREDISPOSITION....1....2....9....8 Reason:_____ NR NA

TABLE 1

Raw Data from The Bathing Related Disease Survey

ITEM	NUMBER
Number of cottages on the lake (Figure supplied by the Mississippi Conservation Authority)	= 1323
Number of cottages which front on the lake (From - MOE Pollution Control Program Report)	= 880
Number of cottages surveyed (All front on the Lake)	= 591
Number of people interviewed	= 1878
Number of interviewed swimmers	= 1861
Number of people who bathed without earplugs or bathing caps	= 1731
Number of reported cases of disease which may have been transmitted by water	= 67
Number of protected bathers (wearing earplugs or a cap) who reported infected ears	= 3
Number of bathers who reported infected ears but did not comment on the use of earplugs or cap	= 2
Number of people who reported ear infections, but did not indicate whether they bathed or not (i.e. did not complete the survey form)	= 1
* Confirmed ear infections in unprotected bathers	= 45
Unconfirmed ear infections in unprotected bathers	= 12
Confirmed ear infections in protected bathers (may not be a waterborne disease)	= 3
Confirmed eye infections in bathers	= 2
Total intestinal upsets in bathers	= 4
Confirmed intestinal upsets in bathers	= 1
Confirmed case of boils	= 1
Total cases of reported waterborne disease	= 67

* NOTE: In the breakdown of infections, a confirmed infection refers to one which was examined by a medical doctor and treatment prescribed. Protected bathers are those who wear earplugs and/or a cap and unprotected bathers swim without them.

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TABLE 2

Frequency Of Various Infections Reported By Bathers

INFECTION	FREQUENCY %
Incidence of all disease reported by bathers, 67/1861	= 3.60%
Incidence of confirmed ear infections in unprotected bathers, 45/1731	= 2.60%
Additional unconfirmed ear infections in unprotected bathers, 12/1731	= 0.69%
Total incidence of ear infections reported by unprotected bathers, 57/1731	= 3.28%
Ear infections as a fraction of total infections, 57 of 67	= 85.07%
Incidence of confirmed ear infections in protected (small sample...) bathers, 3/130	= 2.31%
Incidence of confirmed eye infections in bathers, 2/1861	= 0.11%
Incidence of intestinal upsets reported by bathers, (1/4 were confirmed), 4/1861	= 0.21%
Incidence of confirmed boils in bathers, 1/1861	= 0.05%
Incidence of swimmers itch, 0/1861	= NIL
Incidence of reported disease in non-swimmers, 0/17	= NIL

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TABLE 3

TIME OF YEAR AT WHICH INFECTIONS WERE CONTRACTED

Month	May	June	July	August	September	TOTAL
Number of Infections Reported	1	3	32	28	0	64
%	1.5	4.7	50.0	43.8	0	

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Of those who became infected, 13.6% recorded some predisposition to infection. We cannot judge if this was important for information was collected only from those who became sick. This question was not well recorded, 21.2% of the interview forms were not filled out (Table 4). In future, the importance of this question should be emphasized, and it should be put to all those who are interviewed. The question should be rephrased to read 'have you had a previous ear infection in the last three years?

The ear infections should be considered troublesome as 80% of those with infected ears sought medical aid. The name of the doctor who prescribed treatment was recorded. This would discourage exaggerated claims of sickness since we could verify the claim with their doctor. Verification would take place in the event of a formal epidemiological study.

Swimming Locations of Cottagers

The swimming location of those people who participated in the interviews is reported in Table 5. The cottagers swam almost exclusively in Mississippi Lake (98.3%) with 91.4% swimming only at their cottage. There was no significant difference between incidence of sickness at different swimming locations (Table 5).

Comparison of Sexes of Infected Bathers

In those cottages which reported infections there were 92 male bathers with 31 infected and 89 female bathers with 26 infected. The information on the sexes of bathers was not completed by all cottagers so that the grand total (57) of infected bathers is less in this case. The population of swimmers at cottages reporting infections was examined separately from the total population of swimmers and the results are given in Table 6 and 7 respectively. The rate of infection of male and female swimmers was not significantly different.

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TABLE 4

PREDISPOSITION * TO INFECTION

Predisposition to Infection	Number of Infected Swimmers	%
No predisposition	43	65.2
Some predisposition	9	13.6
Not filled out	14	21.2
TOTAL	66	-

*Predisposition means a condition which favours a new infection (e.g. diabetes, or an ear infection in the past three years)

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TABLE 5

COMPARISON OF FREQUENCY OF SICKNESS WITH SWIMMING LOCATION

Swimming Location	Swimmers Who Became Sick	Health Swimmers From Cottages Reporting Sickness	Health Swimmers From Cottages Without Reported Sickness	TOTAL	Sick	% Swimmers At A Specific Location
Cottage Only	57	131	1476	1664	3.42	91.4
Other Lake Locations Only	4	11	53	68	5.88	3.7
Cottage and Other Lake Locations	5	2	52	59	8.47	3.2
Pools	0	0	7	7	0	0.4
Other *	1	6	15	22	4.54	1.2
TOTAL	67	150	1603	1820	3.68	-

* This is a term for people who cannot describe their swimming locations under the other headings.

$\chi^2 = 5.37$ $P = 0.2511$

(Comparing sick and healthy swimmers with location)

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TABLE 6

COMPARISON OF SEXES OF BATHERS WITH INFECTED EARS

A. Bathers From Cottages Reporting Infections

Swimmers	Infected	Not Infected	TOTAL	% Infected
Males	31	61	92	33.7
Females	26	63	89	29.2
TOTAL	57	124	181	31.5

$X^2 = 0.4$ P = 0.516

TABLE 7

COMPARISON OF SEXES OF BATHERS WITH INFECTED EARS

B. Bathers From All Cottages

Swimmers	Infected	Not Infected	TOTAL	% Infected
Males	31	693	724	4.28
Females	26	732	758	3.55
TOTAL	57	1425	1482	3.85

$X^2 = 0.73$ P = 0.394

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Association of Rates of Ear Infection and Swimming Frequency

For this test low swimming frequency was marked on the interview forms as Code 1 and high swimming frequency as Codes 2 and 3. The total population of interviewed swimmmers was used for the test. It was found that the rate of ear infection was positively correlated with swimming frequency, Table 8. However, the infection rate was independent of swimming frequency among swimmers at cottages from which infections were reported, Table 9. It appears that swimmers who bathe with low frequency can become infected if they bathe at cottage locations from which infections were reported. This may mean a certain amount of cross-contamination of swimmers regardless of swimming frequency.

Another way to look at this data is to compare the frequency of swimming of bathers at cottages reporting infections and at cottages free of infection. A greater proportion of swimmers who swam with high frequency, and were therefore at greater risk, were found at these cottages from which infections were reported. The infection sites may have had nothing to do with the lake-conditions and may have signified only the location of active swimmers. This emphasises the need for data on the density of P. aeruginosa in water at all sites before and after swimming.

Ear Infections in Swimmers with Protected Ears

A sound statistical test (X^2) was not possible with data on swimmers with protected ears because of the small amount of data. However, there was no evidence from the available data, to show that the rate of ear infection depended on swimming frequency among swimmers with protected ears, Table 11.

The rate of ear infection in unprotected swimmers showed a tendency to be higher than the rate of infection in protected swimmers, Table 12.

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TABLE 8

COMPARISON OF RATE OF EAR INFECTION AND SWIMMING FREQUENCY

ALL SWIMMERS

Swimming Frequency	Infected	Not Infected	TOTAL	% Infected
Low (Code 1)	11	1078	1089	1.01
High (Codes 2, 3)	46	585	641	7.32
TOTAL	57	1673	1730	3.29

$X^2 = 48.15$ P = 0.000

TABLE 9

COMPARISON OF RATE OF EAR INFECTION AND SWIMMING FREQUENCY

SWIMMERS FROM COTTAGES REPORTING INFECTIONS

Swimming Frequency	Infected	Not Infected	TOTAL	% Infected
Low (Code 1)	11	35	46	23.91
High (Codes 2, 3)	46	100	146	31.97
TOTAL	57	135	192	29.69

$X^2 = 0.97$ P = 0.326

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TABLE 10

FREQUENCY OF SWIMMING BY BATHERS AT COTTAGES REPORTING EAR INFECTION AND COTTAGES WITHOUT INFECTIONS

	SWIMMERS AT COTTAGE LOCATIONS			
Frequency of Swimming	Cottages Reporting Infections	Cottages Free of Infections	TOTALS	% Reporting Infections
Low (Code 1)	46	1043	1089	4.22
High (Codes 2, 3)	147	495	642	22.90
TOTALS	193	1538	1731	11.15

$X^2 = 142.16$ P = 0.000

TABLE 11

EAR INFECTIONS IN SWIMMERS WITH PROTECTED EARS

	SWIMMERS			
Swimming Frequency	Infected	Not Infected	TOTAL	% Infected
Low (Code 1)	1	53	54	1.85
High (Codes 2, 3)	2	74	76	2.63
TOTAL	3	127	130	2.31

$X^2 = 0.09$ P = 0.770

(NOTE - Insufficient infected swimmers for a sound test.)

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TABLE 12

COMPARISON OF EAR INFECTIONS IN PROTECTED AND UNPROTECTED SWIMMERS

	NUMBER OF SWIMMERS			
	Infected	Not Infected	TOTAL	% Infected
Protected Swimmers	2	74	76	2.63
Unprotected Swimmers	46	595	641	7.32
TOTAL	48	669	717	6.69

$X^2 = 2.25$ P = 0.134

TABLE 13

COMPARISON OF INFECTION RATES OF SWIMMERS AND DEGREE OF COTTAGE USE

	SWIMMERS			
Cottage Use	Infected	Not Infected	TOTAL	% Infected
Low (Code 1)	30	1,085	1,115	2.69
High (Codes 2, 3)	25	562	587	4.25
TOTAL	55	1,647	1,702	3.23

$X^2 = 3.02$ P = 0.082

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It was expected that the protected swimmers would function as a control for those who were unprotected. The protected swimmers became infected, so this control did not function as intended. It may be that those swimmers who wore protective equipment did so because they were particularly sensitive to ear infections and could not function as a control group. In addition, bathing caps are not adequate ear protection, they are worn only to protect the hair, and will be deleted from the question sheet. Non-swimmers also functioned as a control group but very few of these people were interviewed.

Since most cottagers swim at some time of the year the non-swimming group will have to be augmented from another source.

Comparison of Infection Rates and Degree of Cottage Use By Swimmers

Code 1	=	High frequency cottage use and includes the permanent homes
Code 2, 3	=	Low frequency cottage use
Code 4	=	Was rejected and so the total is lower than that previously listed.

There was a strong tendency for swimmers to become infected if they used their cottage frequently (Table 13). This conclusion seems trivial for it is likely that the frequency of cottage use in this test simply reflects the frequency of swimming. The question on frequency of cottage use could be deleted from the questionnaire as redundant.

Age of Swimmers and Ear Infection Rate

Young people are more often infected than adults. The age of swimmers was not collected in this study, but an estimate of their ages could be made. Adults listed themselves first on the questionnaire and referred to themselves usually with full name and title (Mr., Mrs.). Young people were

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referred to as Tommy, Sally and so on. With this as a guide, the population was divided into adults and youths. Some questionnaires had to be rejected because of confusing information and so the grand totals are lower than usual.

Youths became infected at a significantly higher rate than adults, Tables 14, 15. This may only reflect the greater amount of swimming carried out by the younger people. We did not investigate this further because of the imprecise nature of the data. Information on age of swimmers and non-swimmers will be requested in future.

Association of P. aeruginosa with Bathing and Fecal Pollution

The frequency of isolation of P. aeruginosa correlated well with median values of fecal coliforms isolated in sediment in a series of lakes (2) to which Mississippi Lake could be included (Figure 2).

The following observations were made on Mississippi Lake. Fecal pollution at a specific location was considered positive when geometric mean values of fecal coliforms were statistically greater than those of the surrounding water.

1) 5 of 6 sites which could be influenced by cattle watering were positive for fecal pollution.
2) 5 of 6 sites which could be influenced by inflowing streams were positive for fecal pollution. One of these sites was also a cattle watering site.
3) 2 of 4 sites where farms had lake frontage (i.e. no cottages) were positive for fecal pollution. One of these sites was also a cattle watering site.
4) None of the cattle watering sites were positive for P. aeruginosa.
5) There are three main areas for trailer parks. They are all close to public beaches.

   2 of 3 were positive for fecal pollution/

   2 of 3 were positive for the reporting of bathing infections by cottagers.

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FIGURE 2. BETWEEN LAKES COMPARISON P. AERUGINOSA IN SEDIMENT

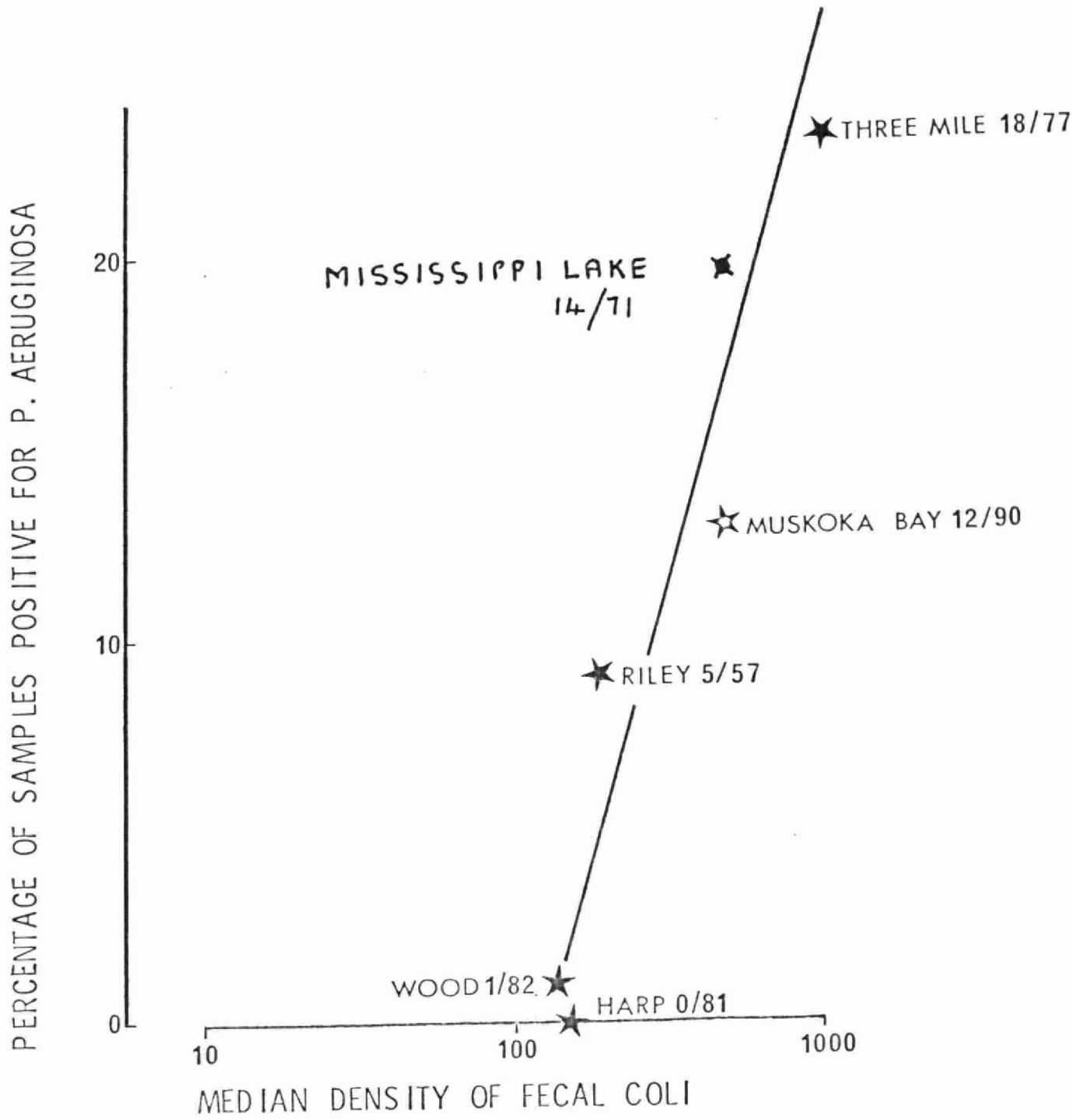

TABLE 14

COMPARISON OF SWIMMER'S AGE AND RATE OF INFECTION

Swimmers	Infected	Not Infected	TOTALS	% Infected
Adults	10	1119	1129	0.89
Youths	46	541	587	7.99
TOTALS	56	1660	1716	3.26

$X^2 = 59.10$ P = 0.000

TABLE 15

COMPARISON OF AGE AND FREQUENCY OF INFECTIONS IN THE POPULATION OF SWIMMERS ONLY FROM COTTAGES REPORTING INFECTIONS

Swimmers	Infected	Not Infected	TOTALS	% Infected
Adults	10	69	79	12.66
Youths	46	59	105	43.81
TOTALS	56	128	184	30.43

$X^2 = 20.66$ P = 0.000

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P. aeruginosa appeared to be related to fecal pollution and bathing, whereas, fecal pollution appeared to be related to a number of factors, such as cattle watering, inflowing streams, and defective septic tanks. An examination of all sampling locations where P. aeruginosa was isolated appears in Table 16 and gives further support to this conclusion. In Table 16, fecal pollution at a given site was assessed from water samples.

These data were retabled in a 2 x 2 table, Table 17, but were insufficient for a sound statistical test. The tendency however for P. aeruginosa to be associated with fecal pollution or bathing can be clearly seen.

Suggested Association of P. aeruginosa with Cottages Reporting Bathing Infections

The sampling locations near cottages reporting infections were compared to the sampling locations near those cottages without reported infections (Table 18). Some sampling locations (stations) which were not thought to be involved in this comparison were deleted. These stations monitored inflowing streams, stretches of shore without cottages, shoreline where cottagers were not interviewed, and midlake stations. The data was reorganized using both sediment and water samples (Table 19).

P. aeruginosa was found at 19.2% of those cottage locations reporting bathing infections, and at only 3.2% of those cottage locations free of bathing infections. It was felt that about twice as much data would be required for a truly significant test. The data indicated only a suggested association since the data on the presence of P. aeruginosa was gathered the year following the ear infections, and it is surprising that a correlation between them survived for a year. This may mean that there is something unusual about these P. aeruginosa positive sites that assists the survival of the bacteria (e.g. continuing fecal pollution). Perhaps the bacteria survived till the following year after contamination of the site by infected swimmers. This sort of question could be investigated in the future.

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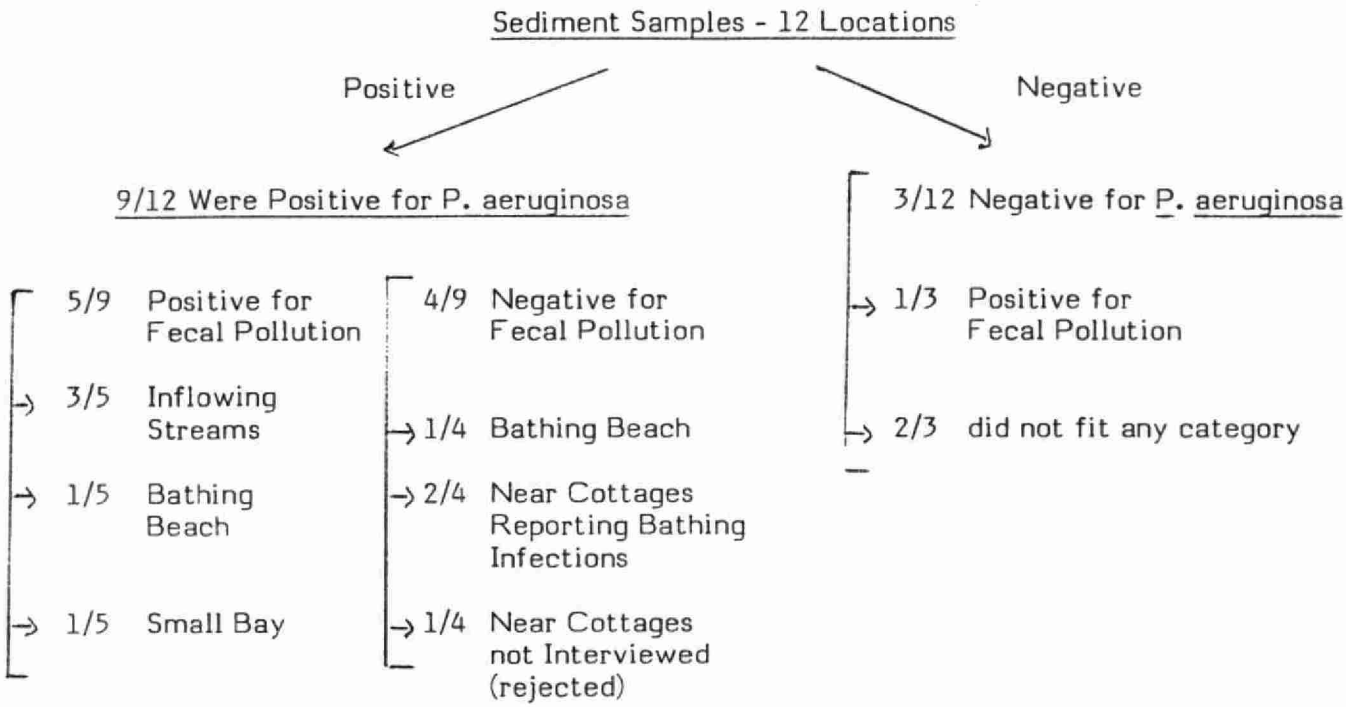
TABLE 16

ASSOCIATION OF P. AERUGINOSA WITH FECAL POLLUTION AND BATHING INFECTION



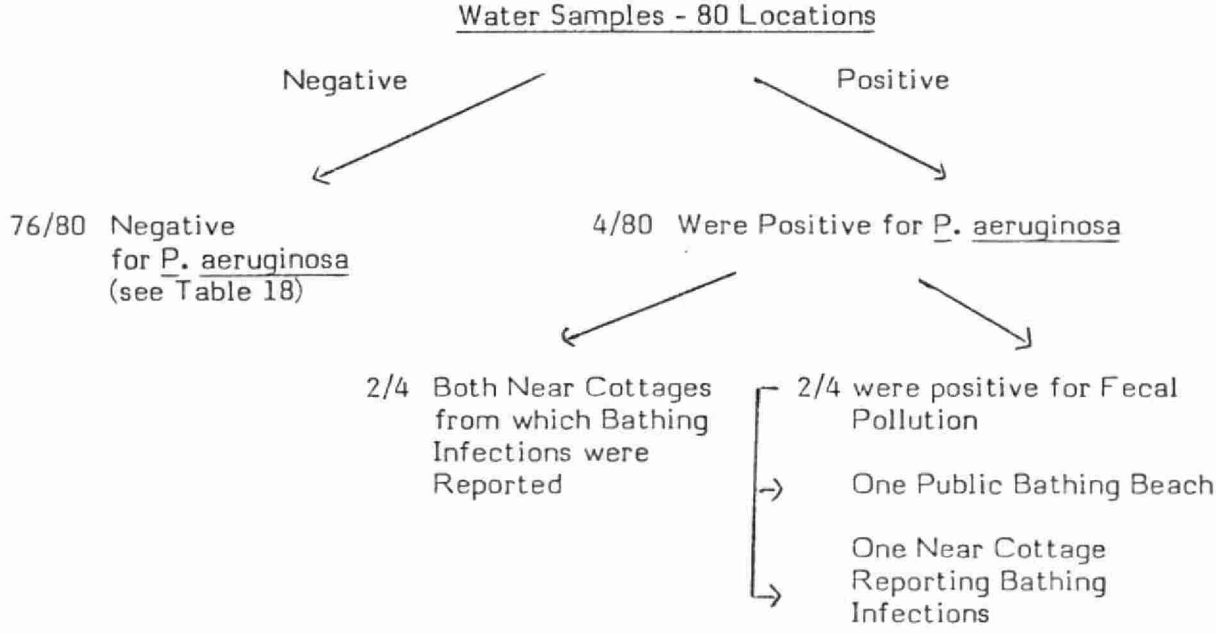


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TABLE 17

ASSOCIATION OF P. AERUGINOSA WITH BATHING AND FECAL POLLUTION

	Presence or Absence of P. aeruginosa		
	Present	Absent	TOTALS
Locations Where Fecal Pollution or Bathing Effects Were Noted	8	1	9
Other Locations	0	2	2
TOTALS	8	3	11

$X^2 = 6.519$ P = 0.0107

TABLE 19

ASSOCIATION OF P. AERUGINOSA WITH COTTAGE LOCATIONS FROM WHICH BATHING INFECTIONS WERE NOTED

	Presence of P. aeruginosa (PA)			
	+ve	-ve	TOTAL	% Positive (PA)
Cottage Locations Reporting Infections	5	21	26	19.2
Cottage Locations With No Infections	1	30	31	3.2
TOTAL	6	51	57	10.5

$X^2 = 3.85$ P = 0.0499

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TABLE 18

ASSOCIATION OF P. AERUGINOSA WITH COTTAGES REPORTING EAR INFECTIONS

Sampling Stations Near Cottages Reporting Infections	Sampling Stations Near Cottages Without Infections
4	3
6	15
7	17
9	18
11	19
12	21
14	25
16	26
23	27
30	28
31	30
33	34
36	37
38	39
55	40
58	42
59	46
60	52
* 61 S	56
72 W W	* 57 S
74	62
* 75 W	63
60	64
	65
	68
	69
	71
	73
	77
TOTAL - 23 Station - 52 Sampling Opportunities	- 29 Stations - 62 Sampling Opportunities

* Sediment sampled at these locations.

S = Sediment contained P. aeruginosa

W = Water contained P. aeruginosa

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Association of Defective Septic Tank Systems with Bacteriological Indicators of Fecal Pollution

Septic tank information was obtained from the M.O.E. Mississippi Lake Cottage Pollution Control Program. The condition of the septic tanks was color-coded on a series of large-scale maps for the Pollution Control Program report (4). These maps were too large to be reproduced in this report. An abbreviated map is used (Figure 3). However, the data for individual areas were calculated from the color-coded maps. The overall statistics were taken directly from the Pollution Control Program report. A comparison of several areas, 26B4, 4B6, and 13B5 and 6, could be clearly seen from the color-coded coded maps to be different from the lake as a whole. Table 20, areas 26B4, 4B6 and 13B5 and 6, showed signs for fecal pollution whereas area 4B7 did not give evidence of pollution. (See separate bacteriological report - (4).

Fecal pollution was therefore associated with some areas where large numbers of flooded septic tanks were found, e.g. areas 25B4 and 13B5 and B6. A high concentration of seriously substandard septic tanks was associated with fecal pollution in area 4B6.

Minor problems can also be seen in these areas and definite proof of pollution from septic tanks cannot be obtained from the data. The association of fecal pollution with blocks of defective septic tanks is the kind of observation that can be made from this survey data, which falls short of proof, but when the associations are repeated often enough they become convincing. In two past studies, bacteriological water quality was improved after a septic tank cleanup program. The best example of this was obtained during the study of Cameron Lake (5).

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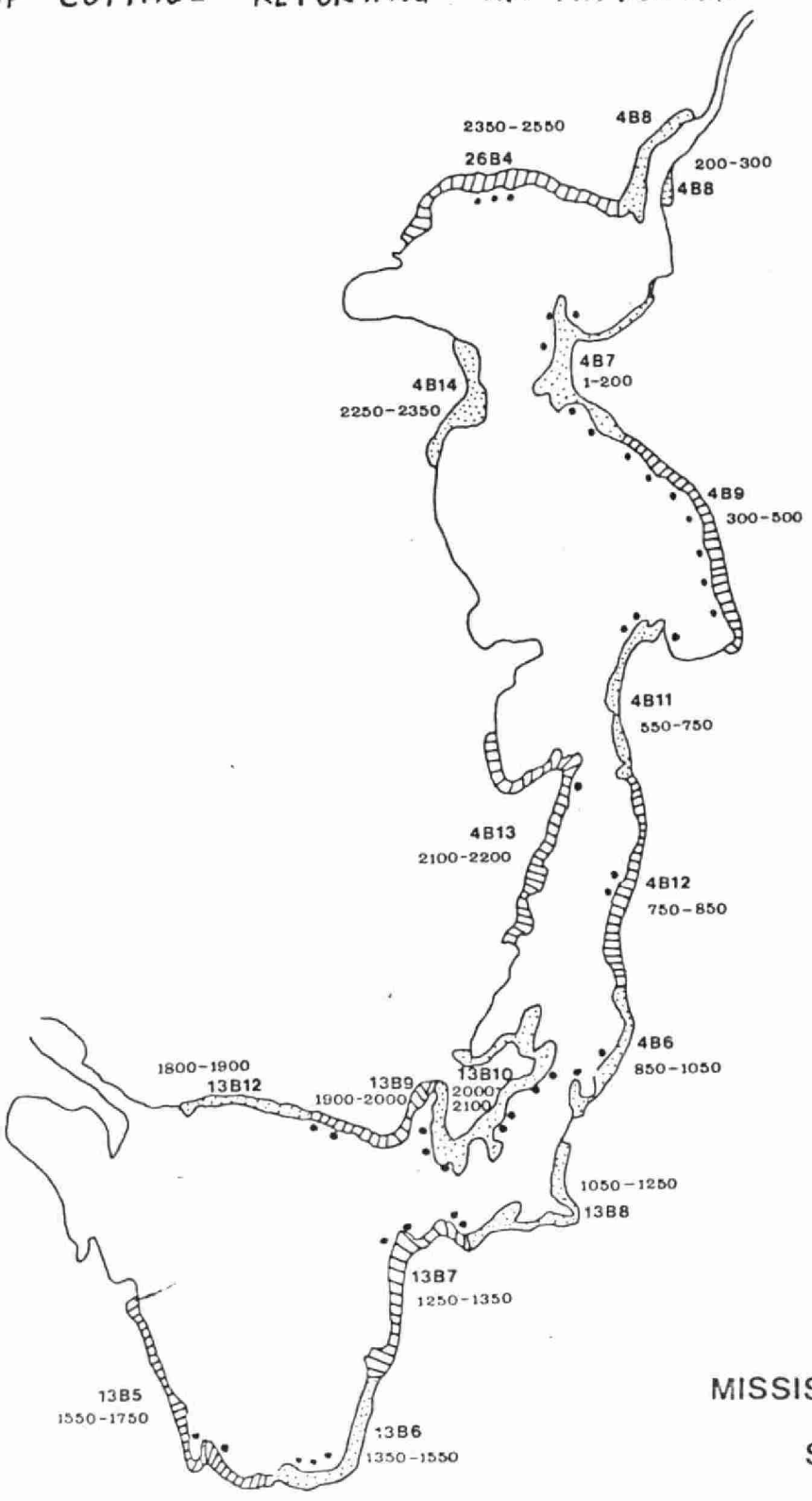
FIGURE 3 - LOCATION OF INFECTION SITES

SITE OF COTTAGE REPORTING AN INFECTION.



MISSISSIPPI LAKE

STUDY AREA

STUDY SECTIONS 1976.

SOURCE: ONTARIO HYDRO, EASTERN REGION
SCALE: 1:50000

TABLE 20

CONDITION OF SEPTIC TANKS IN SELECTED LOCATIONS IN MISSISSIPPI LAKE

Septic Tank Status	Overall	26B4 *	4B7	4B6	13B5 + 13B6
Satisfactory %	57.0	42.6	46.7	45.0	42.3
Seriously Substandard %	19.2	17.0	28.3	45.0	11.5
Nuisance Wash Water %	6.4	0.0	11.7	10.0	9.0
Flooded %	17.0	40.4	13.3	0.0	37.2
Direct Polluter %	0.4	0.0	0.0	0.0	0.0
TOTAL %	100.0	100.0	100.0	100.0	100.0

* See Figure 3 for Coded Locations.

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CONCLUSIONS

1. Ear infections reported from Mississippi Lake cottagers are related to swimming. A study of otitis externa in swimmers and non-swimmers showed that the disease was related to swimming (Hoadley and Knight - 6). The conclusion that ear infections were related to swimming in Mississippi Lake was made by demonstrating that as swimming frequency increased, the frequency of ear infections increased also.
2. The age, but not the sex of the bather, was an important factor governing infection.
3. P. aeruginosa was associated with sites having fecal pollution and/or bathing beaches and sites from which bathing infections were reported.
4. It was not proved that waterborne P. aeruginosa actually caused the bathing infections. A more complex study could however lead to that conclusion. In another study, otitis externa in swimmers from swimming pools was shown to be related to the levels of P. aeruginosa surviving chlorination (9).
5. Some of the fecal pollution observed in Mississippi Lake was associated with large blocks of defective septic tanks.
6. The data from the survey was tested in a variety of ways which are summarized in Table 21.
7. The survey form was redesigned (Figure 4).
8. The incidence of bathing related disease seemed to be low (3.60%) and was close to that reported for some other lakes (2).
9. The largest type of bathing related disease, 57 of 67 reported infections, was infection of the ear.

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TABLE 21

STATISTICALLY TESTED COMPARISONS

Characteristic	Comparison	X^2 Significance
Infection Rates	Male vs. Female Swimmers	NS
Infection Rates	Low vs. High Frequency Swimmers (Total population)	SD
Infection Rates	Low vs. High Frequency Swimmers (Population from cottages with infections)	NS
Infection Rates	Low vs. High Degree of Cottage Use	NS *
Infection Rates	Low vs. High Frequency of Swimming (Protected swimmers only)	NS
Infection Rates	Protected vs. Unprotected Swimmers	NS
Infection Rates	Age: Adults vs. Youths	SD
Swimming Frequency	Protected vs. Unprotected Swimmers	SD
Swimming Frequency	Unprotected Swimmers: Whole Population vs. Those Swimming From Cottages Reporting Infections	SD
Swimming Frequency	Swimmers at Cottages Reporting Infection vs. Those at Cottages Free of Infections	SD
Presence of *P. aeruginosa*	Cottages Reporting Infections vs. Cottages Without Infections	SD

NS = Not significant P = 0.05, SD = Significant P = 0.05, NS* = Significant P = 0.1

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Ministry of the Environment

Ontario

NAME

ADDRESS

LOCATION ON Lake

INTERVIEW NO

INFORMATION ON BATHING RELATED INFECTIONS

Q1. In the last year, indicate if any one who used this cottage suffered from ear infections, eye infections, skin infections, intestinal upsets, or hepatitis?

NO 1
YES.....2
NR.....9

Q.3 Do you use lake water for drinking purpose? 1.....2.....

Q.4 Is the water treated? 1.....2.....

Q2. List all the members of the family who used the cottage. Include non=swimmers.

NO	Name	Sex	Age	Frequency of Water Contact	Swimming Location	Wears Ear Plugs or cap	Wets head while swimming	Dives	Previous Ear Infections
1				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
2				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
3				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
4				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
5				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
6				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
7				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
8				1 2 3 4	1 2 3 4	1 2 3	1 2	1 2	1 2 L R
	CIRCLE THOSE WHO SUFFERED FROM INFECTIONS AS IN Q1			1=less than 3 times/wk 2=3-5time/wk 3-more than 5 time/wk 4=did not swim	1=cottage only 2=other locations on lake 3=pools 4=other	1=NO 2=plugs 3=cap	1 = NO 2 = YES	1 = NO 2 = YES	1 = NO 2 = YES L = Left Ear R = Right Ear * SPECIFY

MOE 0511 5/77

FIGURE 4

FIGURE 4 (REVERSE)

AFFLICTED PERSON #_____ NAME_____ INTERVIEW NO.:

AFFLICTION: Ear Infection..... NO=1 Yes=2 NR=9
Eye Infection.....1.....2.....9
Skin Infection.....1.....2.....9
Intestinal Upsets.....1.....2.....9
Hepatitis.....1.....2.....9

OCCURRENCE	SUMMER:		MONTH:						
	NO=1	Yes=2	May=1	June=2	Jul=3	Aug=4	Sept=5	NR=9	NA=8
Ear Infection.....									
Eye Infection.....	1	2	1	2	3	4	5	...9	...8
Skin Infection.....	1	2	1	2	3	4	5	...9	...8
Intestinal Upsets.....	1	2	1	2	3	4	5	...9	...8
Hepatitis.....	1	2	1	2	3	4	5	...9	...8

TREATMENT:	DOCTOR				NAME	ADDRESS
Ear Infection.....	NO=1	Yes=2	NR=9	NA=8	_____	_____
Eye Infection.....	No=1	Yes=2	NR=9	NA=8	_____	_____
Skin Infection.....	1	2	...9	...8	_____	_____
Intestinal Upsets.....	1	2	...9	...8	_____	_____
Hepatitis.....	1	2	...9	...8	_____	_____

MEDICATION ..... NO=1 Yes=2 NR=9 NA=8 Type:_____ NR NA
PREDISPOSITION.....1 ...2 ...9 ...8 Reason:_____ NR NA

AFFLICTED PERSON #_____ NAME_____ INTERVIEW NO.:

AFFLICTION: Ear Infection..... NO=1 Yes=2 NR=9
Eye Infection.....1 ...2 ...9
Skin Infection.....1 ...2 ...9
Intestinal Upsets.....1 ...2 ...9
Hepatitis.....1 ...2 ...9

OCCURRENCE	SUMMER:		MONTH:						
	NO=1	Yes=2	May=1	June=2	Jul=3	Aug=4	Sept=5	NR=9	NA=8
Ear Infection.....									
Eye Infection.....	1	...2	1	2	3	4	5	9	...8
Skin Infection.....	1	...2	1	2	3	4	5	9	...8
Intestinal Upsets.....	1	...2	1	2	3	4	5	9	...8
Hepatitis.....	1	...2	1	2	3	4	5	9	...8

TREATMENT:	DOCTOR				NAME	ADDRESS
Ear Infection.....	NO=1	Yes=2	NR=9	NA=8	_____	_____
Eye Infection.....	NO=1	Yes=2	NR=9	NA=8	_____	_____
Skin Infection.....	1	...2	...9	...8	_____	_____
Intestinal Upsets.....	1	...2	...9	...8	_____	_____
Hepatitis.....	1	...2	...9	...8	_____	_____

MEDICATION.....NO=1 Yes=2 NR=9 NA=8 Type:_____ NR NA
PREDISPOSITION.....1 ...2 ...9 ...8 Reason:_____ NR NA

* Skin infection should include scratch or wound infection

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